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UNITED STATES
DEPARTMENT OF THE INTERIOR
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SOME INFORMATION ON EXTINGUISHING AN ANTHRACITE REFUSE-BANK FIRE NEAR MAHANOY CITY, PA.

BY

R. D. LEITCH

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UNITED STATES DEPARTMENT OF THE INTERIOR - BUREAU OF MINES

SOME INFORMATION ON EXTINGUISHING AN ANTHRACITE REFUSE-BANK FIRE NEAR MAHANOY CITY, PA.[1]

By R. D. Leitch[2]

INTRODUCTION

Spontaneous firing of coal during storage and even during shipment has long been a serious problem, especially in some regions and with some coals, and methods for preventing such firing have been investigated at intervals for more than 70 years. Spontaneous or other firing of coal waste, either outside or inside mines, has also been a problem probably for as long as mining has been practiced extensively. Much trouble has been caused by such fires, and much money has been spent in attempts to extinguish them. It is known generally that surface waste banks in bituminous-coal fields are very likely to take fire sooner or later, but it is not known so generally that anthracite refuse-bank fires also are common and that at least some of them are more serious in their effect and results than being regarded merely as a nuisance. These surface refuse fires probably would have attracted much more than local attention long ago had it not been that they usually cause no more serious trouble than air pollution.

A few supposedly effective methods of preventing or extinguishing spontaneous fires have been reported rather recently. Unless one or more of these prove to be widely applicable, methods of solving these problems are no more certain today than they have been for many years.

The well-known methods for preventing spontaneous firing of coal are underwater storage, maintenance of storage piles at a maximum height, below which the heat generated by oxidation can be dissipated, sizing and either packing the piles to cut off air or keeping them loose and well-ventilated by cribbing or other means, and close observation to detect abnormal heating under the three last-named methods. To these may be added the effective but less practicable measure of separating and burning, under controlled conditions, the combustible material in the waste.

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[1] The Bureau of Mines will welcome reprinting of this paper provided the following footnote acknowledgment is used: "Reprinted from Bureau of Mines Information Circular 7104."

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Quenching with water or smothering with incombustible material often has been effective in extinguishing relatively small fires in stored coal, but usually it is advisable, if not necessary, to dig out the hot or burning coal. The same methods may be effective with waste-pile fires, but are less likely to be employed, as the lower value of the waste does not justify the costs incident to the greater areas and volumes involved and the presence of more difficult physical handicaps.

Data are not available on the total losses caused by burning bank fires or on the cost when it has been necessary to extinguish them. These losses and costs, however, now must aggregate several million dollars, to which many millions of dollars certainly will be added in the future unless more effective and less costly methods of handling these troublesome fires are discovered. Evidently, further studies to this end are well-justified, if not demanded; the Federal Bureau of Mines is making studies on this subject in and around all kinds of mines that have or are suspected of going to have fires in waste piles.

With this thought in mind, officials of the Philadelphia & Reading Coal & Iron Co. have permitted publication of certain experiences in connection with the recent extinguishing of an extensive waste-bank fire at the St. Nicholas colliery in the Western Middle anthracite field near Mahanoy City, Pa.

ACKNOWLEDGMENTS

Thanks are due H. F. McCullough, engineering manager, and H. L. Bailey, mining engineer, Philadelphia & Reading Coal & Iron Co., Pottsville, Pa., for the opportunity to obtain the information presented in this paper.

All data were obtained from the official report or in conference and correspondence with Joseph Petusky, an engineer in the Mahanoy City division of the Philadelphia & Reading Co., who acted as general foreman during the entire work.

Petrographic identification of the crystalline material found during excavation near churn-drill holes was made by W. H. Foster of the Gas and Dust Section, Pittsburgh Experiment Station, under direction of H. H. Schrenk.

HISTORY OF THE ST. NICHOLAS REFUSE-BANK FIRE

The first evidence of fire in the St. Nicholas waste pile was noted on November 13, 1937, when carbon monoxide was found in No. 1 rock hole to the Holmes vein off No. 15 tunnel, No. 7 plane level, at Maple Hill colliery. The following day, November 14, a surface inspection was made of the region overlying the underground workings affected. Fire could not be seen, although smoke and heat were found on the north slope of the St. Nicholas bank near the junction with the Maple Hill bank, and steam was observed coming from the top of the St. Nicholas bank and along the slope directly south of the place where smoke was observed. Three days

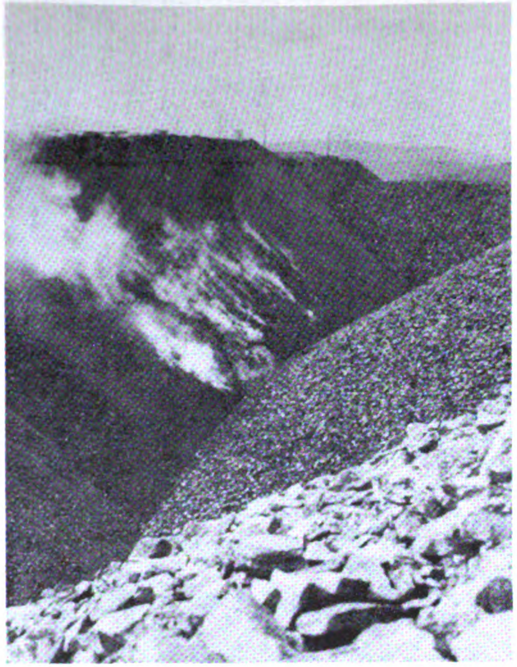

Figure 1.- View, looking west, of St. Nicholas (left) and Maple Hill refuse banks and fire, November 17, 1937.

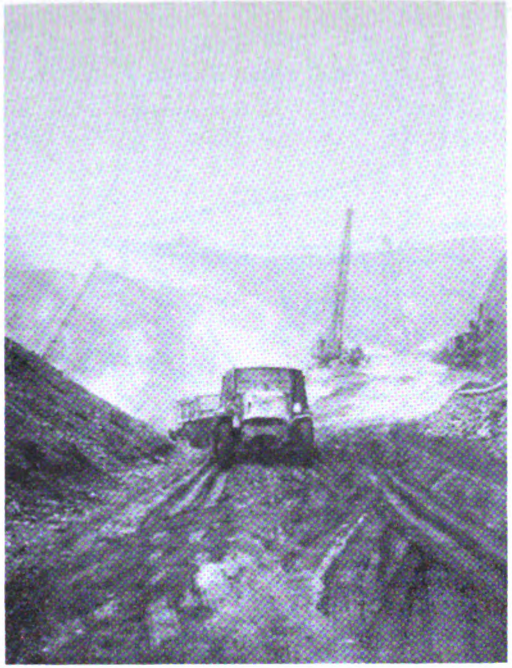

Figure 2.- General view of excavating equipment in operation.

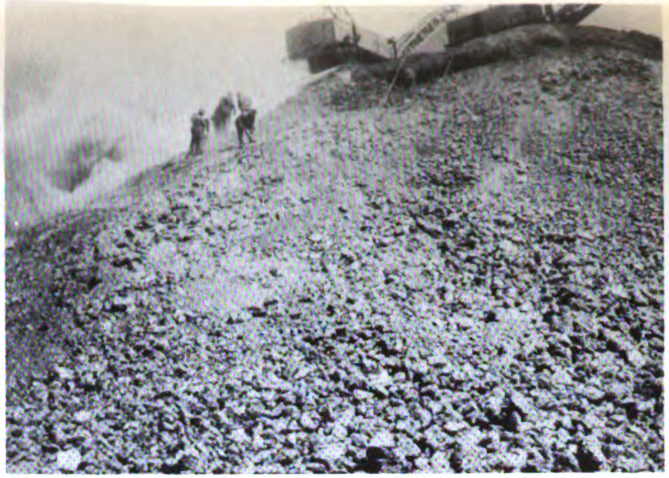

Figure 3.- Drilling in hot clinkers along north portion of fire island.

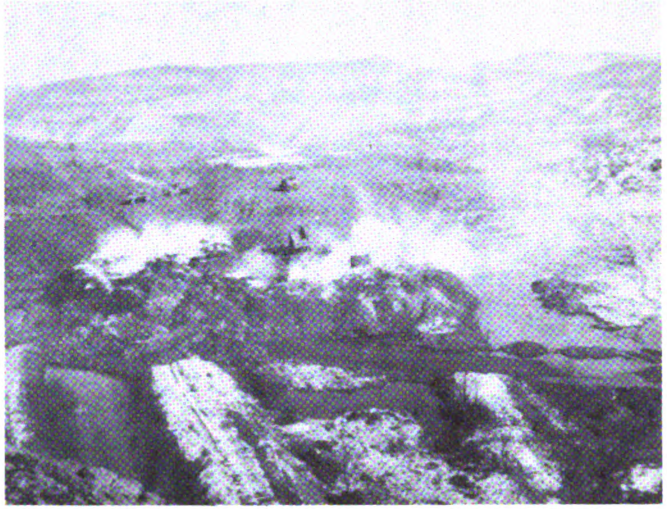

Figure 4.- View of east and west dumps for excavated material.

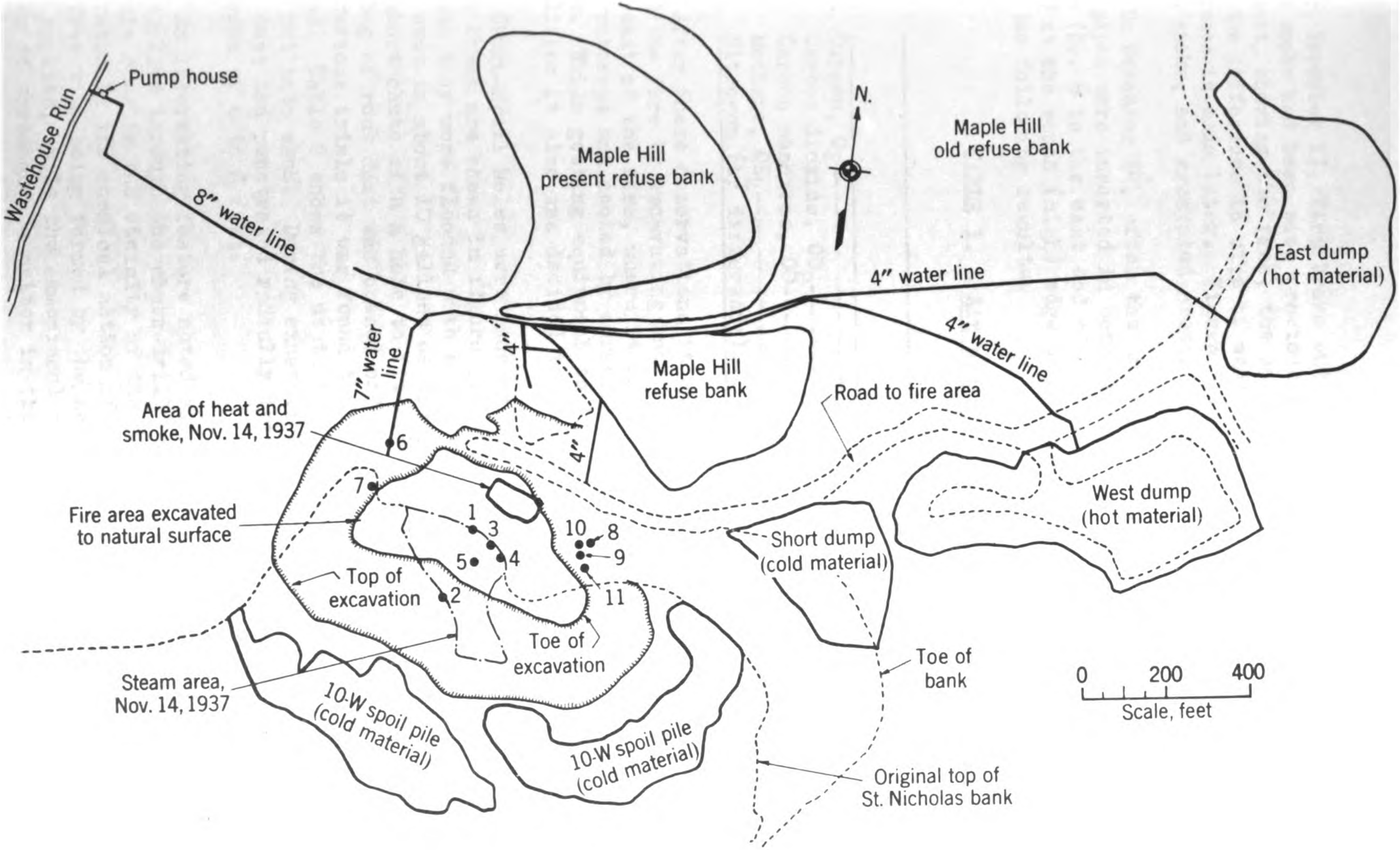

Figure 5.—Plan of refuse dumps.

later, November 17, fire broke out on the surface of the St. Nicholas bank where smoke had been seen previously. Figure 1 is a view of this area looking west, showing the fire, the south slope of the Maple Hill bank, and also the difference in size of waste material in the two banks, to which reference is made later. Figure 5 is a plan of the original waste piles, fire, smoke, and excavated areas, water lines, and test holes.

On November 14, after the smoke and steam areas had been noted, test pipes were inserted in both areas. Air analyses from two of these pipes (No. 6 in the east end of the smoke area at a depth of 5 feet and No. 7 at the south (high) edge of the steam area at a depth of 9 feet) gave the following results.

TABLE 1. - Air analyses from test pipes

	No. 6 pipe, percent	No. 7 pipe, percent
Oxygen, O_2	7.6	1.0
Carbon dioxide, CO_2	10.55	20.3
Carbon monoxide, CO	2.15	1.05
Methane, CH_4	.23	1.01
Nitrogen (by difference)	79.47	76.64

After these observations it was decided, on November 17, 1937, to fight the fire by excavating and trucking the burning material to an area east of the fire, where it could be isolated from other banks or coal outcrops and cooled by spraying with water pumped from a nearby creek. While getting equipment to the site and installing pumping facilities it also was decided to attempt other control measures.

Churn-drill holes were made to determine the extent of the fire. These holes are shown in figure 5. After the holes had served their purpose they were flooded with a suspension of 1 bag (80 pounds) of rock dust in about 10 gallons of water and abandoned. A wooden platform and short chute with a hole to fit over the drill-hole casing were used; the bag of rock dust was opened and the contents washed down the hole. By previous trials it was found that this procedure gave the proportions stated. Table 2 shows the depth of these holes and the quantity of rock dust put into each. During excavations later it was observed that the rock dust had penetrated radially into the surrounding material for a distance of 6 to 8 feet.

An interesting feature noted at the time the rock-dust solution was applied through the churn-drill holes was the presence of a faint ammonia odor in the vicinity of the holes. The ammonia probably was liberated by the chemical action of free lime on ammoniacal compounds, the free lime being formed by the action of heat on the limestone rock dust applied, while the ammoniacal compounds resulted from semidistillation of carbonaceous matter in the refuse bank.

TABLE 2.- Quantity of limestone rock dust put into churn-drill holes

(Mixed with water to form solution of 1 bag limestone dust to 10 gallons water)

Hole No.	Depth of hole, feet	Quantity of rock dust, bags
1	165	640
2	200	-
3	158	377
4	187	621
5	184	-
6	165	-
7	175	-
8	76	189
9	82	-
10	76	400
11	42	-
12	35	197
13	36	88
14	46	77
15	44	190
16	38	93
17	38	130
Total	1,747	3,002

The churn-drill holes were started on November 19, and temperature readings were taken at the various depths as the drilling progressed. It was necessary to case all holes to full depth. Those not exceeding 120 feet in depth were cased with 10-inch pipe, but it was necessary in deeper holes to use 8-inch-diameter liner pipe as an inner casing to prevent buckling, and this was the procedure on all holes exceeding 120 feet in depth. The depths, temperatures, and dates of recording are shown in table 3.

Holes 1, 2, 3, 4, and 5 were drilled on top of the St. Nicholas refuse bank to determine the limit of the fire southward. Fire was found in hole 3 at a depth of 158 feet, and it was abandoned owing to the presence of carbon monoxide (CO) in the hot vapor coming therefrom. The hole was later filled with rock-dust solution and the casing pulled out. It will be noted that the temperature in holes 1, 3, 4, and 5 increased with the depth of the hole, while the temperature in hole 2 reached a maximum at half the final depth. This indicated that hole 2 was beyond the south limit of the fire and that the fire was situated near the bottom of the bank. The high temperature at the half-way point in hole 2 probably was due to the heat from the fire, which followed vents or layers of coarser material segregated at the time the refuse material was dumped on the bank.

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TABLE 3.- Temperatures in churn-drill holes

Hole No.	Date	Depth of hole, feet	Temperature in hole, °F.	Remarks
1	11-20-37	25	127	Bottom of hole approximately 20 feet above natural surface. Casing buckled in hole. 160 feet of 10-inch casing in hole.
	11-21-37	109	119	
	11-22-37	125	136	
	11-23-37	145	174	
	11-24-37	165	189	
2	11-23-37	14	133	Hole drilled at location of No. 7 test pipe. Temperature in test pipe 187° F. Hole completed to clay at 200 feet.
	11-24-37	64	140	
	11-24-37	91	158	
	11-25-37	115	164	
	11-25-37	120	180	
	11-26-37	123	143	
	11-26-37	140	140	
	11-27-37	200	130	
3	11-24-37	23	144	Moved off of hole at 158 feet; 0.2 percent CO in hot vapor and fumes discharging from hole.
	11-24-37	50	108	
	11-25-37	90	125	
	11-25-37	136	154	
	11-26-37	158	209	
	11-26-37	158	700	
4	11-27-37	34	143	Hole completed to clay at 187 feet.
	11-27-37	75	134	
	11-29-37	80	150	
	11-30-37	128	155	
	12-1-37	187	170	
5	11-27-37	42	110	Hole completed to clay at 184 feet.
	11-28-37	72	124	
	11-29-37	148	142	
	11-30-37	184	175	

TABLE 3.- Temperatures in churn-drill holes--Contd.

Hole No.	Date	Depth of hole, feet	Temperature in hole, °F.	Remarks
6	12-18-37 12-19-37 12-20-37 12-21-37	46 109 165 165	50 51 68 54	Completed to clay at 165 feet.
7	12-20-37 12-21-37 12-22-37	39 130 175	78 68 58	Completed to clay at 175 feet.
8	1- 2-38 1- 3-38	54 76	50 38	Completed to clay at 76 feet.
9	1- 3-38 1- 4-38	52 82	40 46	Completed to clay at 81 feet.
10	1- 4-38 1- 5-38	52 76	42 48	Completed to clay at 76 feet.
11	1- 6-38	42	52	Moved off due to slide.
12	1-13-38	35	59	Completed to clay at 35 feet.
13	1-14-38	36	62	Completed to clay at 36 feet.
14	1-14-38	46	76	Opening 35 feet to 45 feet.
15	1-15-38	44	60	Completed to clay at 44 feet.
16	1-16-38	38	58	Completed to clay at 38 feet.
17	1-16-38	38	60	Completed to clay at 38 feet.

Holes 6 and 7 were drilled west of the fire area at the junction of the Maple Hill and St. Nicholas refuse banks. High temperatures were not noted in these holes, indicating that the fire had not penetrated to this point.

Holes 8, 9, 10, and 11 were drilled east of the fire area. It was the intention to continue drilling additional holes farther south at this point and flood the holes with rock-dust solution to form a barrier at the east end; however, the project was abandoned because of bank slides in the vicinity. High temperatures were not noted in these holes.

Holes 12, 13, 14, 15, 16, and 17 were drilled on the Maple Hill refuse bank at the level of the truck road to form a rock-dust barrier at the section of the truck road connecting the fire area to the Maple Hill refuse bank. When the drilling was completed the holes were flooded with rock-dust solution. Abnormal temperatures were not noted in these holes.

The method of applying limestone rock-dust solution through holes made in the bank has been used successfully to control refuse-bank fires at other locations. Owing to difficult drilling conditions on the St. Nicholas refuse bank, this method of application of rock dust was limited to locations where the churn drilling would not interfere with the excavation of the fire and the completed test holes could be flooded with rock-dust solution.

On November 21, while churn drilling was in progress, an attempt was made to smother the fire by rock-dusting the surface. The rock dust was spread by chutes extending from the top of the bank down to the fire area. The chutes were moved laterally along the bank until the surface was covered as desired. A total of 700 tons of rock dust was used to cover an area of 7,500 square feet to a depth of 2 to 3 feet. The procedure appeared to be ineffective as a fire-control measure.

EXCAVATION AND TRANSPORTATION

Following the decision on November 17 to excavate the burning material, it was necessary to construct a truck road to the vicinity of the fire. This was no small job, as it required construction of about 1,200 feet of road along the slope of the old Maple Hill refuse bank. For 800 feet the road had an ascending grade of 6 percent to the junction of the Maple Hill and St. Nicholas banks and a descending grade of 8 percent to the fire area to keep the depth of excavation in that area within the limits of the small draglines used later.

It was necessary to install water lines and pumps to quench the burning material. The nearest source of water available in sufficient quantity for the purpose was Waste House Run. A 1,000-g.p.m. electric centrifugal pump was installed to operate under 275-foot head and later a second, similar pump was installed at the same site for emergency use. In all, about 1,000 feet of 8-inch, 300 feet of 7-inch, and 4,000 feet of 4-inch water pipes were installed. These installations are shown on figure 5.

During construction of the truck road, several operators on the excavating equipment were overcome by fumes from the fire, and it was decided to install forced ventilation. Accordingly, two centrifugal blower fans were placed in fresh air on the Maple Hill refuse bank and delivered air through a 20-inch Ventube to the excavating equipment and trucks in the pit. As the area of the pit increased during excavation, natural ventilation increased and the artificial ventilation system was unnecessary after about 3 months of work (February 1938).

The general plan for extinguishing the fire was to isolate the burning material, load it on trucks, and quench at a selected site east of the fire. In somewhat more detail, the plan was first to isolate the Maple Hill bank by excavating with small dragline shovels a trench to natural surface between the two banks to prevent spread of the fire into that bank; then, as much as possible of the material overlying the fire in the St. Nicholas bank was to be removed by a large dragline shovel and cast back on top of the refuse pile; and finally, the remaining material, including that actually on fire, was to be transported by trucks as first mentioned.

A contractor having the necessary equipment was engaged for this work. The equipment consisted of a model 10-W Monighan dragline, a 3-W Monighan dragline, a 55-B dragline, two 52-B draglines, and a 43-B shovel. All of this equipment was Diesel-powered except the gasoline-driven 43-B shovel. The transportation equipment consisted of 20 gasoline-driven Mack dump trucks of 9-cubic-yard capacity. A general view of this equipment in operation is shown in figure 2, beginning at upper left with the boom of the 10-W dragline with the 43-B shovel at the extreme right, and two dump trucks in the center foreground. The 43-B shovel and one 52-W dragline were used in constructing the truck road.

After the trench had been excavated along the Maple Hill bank, similar trenches were excavated roughly at right angles southward along the east and west limits of the fire, and finally isolation was completed by trenching along the south limit of the fire. Thus, an island of burning material was left remaining in the pit except for the main truck road, a necessary connecting link. However, this part of the road was a clay fill, so that the fire remained completely isolated to the end of the work.

The fire was completely isolated from the adjoining banks on April 25, 1938, and from this time on it was a matter of excavating the burning material and hauling it to the dump area, where it was cooled with water. While excavating the burning material near the center of the fire area, the top of a 6- by 6-foot shaft to the crop of the Little

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Primrose coal bed was uncovered. As the earth was disturbed here and quite warm from the overlying fire, it was decided to determine whether the Little Primrose bed had ignited by excavating the clay to the bottom of the shaft (a distance of 20 feet) where a manway was found. Exploration down the pitch for some distance showed no trace of fire or heating, so the shaft opening was covered with boards and clay and abandoned.

Considerable difficulty was experienced in excavating the northern portion of the island, where the coarser rock of the Maple Hill bank was fused to form a massive clinker that extended from the east to the west limits of the fire. This clinker had to be drilled and shot, which was accomplished by first cooling with water the area to be drilled. Even then it was impossible to drill holes deeper than 4-1/2 feet, as heat of the clinker below this depth caused flattening of the drill bit. Holes were 3 inches in diameter, spaced 6 feet apart. The charge for each hole consisted of two 2- by 12-inch sticks of 40-percent dynamite wrapped in sheet asbestos. Figure 3 shows workers drilling in this clinker.

Excavation of the burning material was completed May 28, 1938. It is estimated that a total of 1,685,300 cubic yards of material was moved, of which 786,400 cubic yards was moved by the 10-W Monighan dragline located on top of the St. Nicholas bank and 898,900 cubic yards was moved by the smaller machines. Of the total quantity of material handled by the smaller machines, 798,900 cubic yards was loaded into trucks and hauled to the disposal area.

DISPOSITION OF BURNING MATERIAL

The burning material from the fire was taken to locations shown in figure 5 as East dump and West dump. These dumps are situated on natural surface between the outcrops of the Primrose and Orchard coal beds. The unburned (cold) material was disposed of on a third or Short dump situated along the slope of the St. Nicholas bank and 500 feet east of the fire area.

The burning material was dumped in individual piles until the dump area was covered, then the whole area was cooled with streams of water from a number of hose lines. After the piles had cooled sufficiently they were leveled with a bulldozer and another layer of hot material was added after due precautions had been taken to make certain that the previous layer was completely cooled. Figure 4 shows the procedure of dumping and cooling on the east and west dumps. Trucks were run over previously leveled surfaces.

GENERAL HEALTH AND SAFETY DURING WORK

Although 87 persons engaged in the work suffered some sort of injury, the health and accident record is remarkably favorable when it is considered that during a total of more than 28,000 man-days in hazardous work (for much of the time in winter), no fatalities occurred and the injuries were mostly of a minor nature.

A more detailed analysis of the data shows that 55 of the 87 injuries required no lost time. Classified as to cause, 19 accidents were due to falls and 7 to falling objects, 22 were caused by foreign objects in the eye, and 3 each to smoke or fumes and to working under abnormally dusty conditions. Nineteen injuries, exclusive of falls from trucks, were sustained in operation or repairs to trucks, and falls from trucks caused 10 of the 19 accidents from falls; 20 of the 32 lost-time accidents were from these causes. Thirty of the 87 injuries were due to operation of trucks. Fourteen accidents were due to miscellaneous causes too varied to enumerate. The most serious injuries are listed in table 4:

TABLE 4.- Nature and cause of injuries and days lost

Nature of injury	Cause	Days lost
Burns of eyes...........	Alcohol blew out of air tank.....	24
Bruises and sprains of entire body........	Coat caught on drive shaft of truck, pulling man into machinery......................	28
Fractured elbow..........	Fell from shovel catwalk.........	43
Squeezed chest...........	Caught between drill and casing..	43
Strained and bruised back..................	Motor stalled and truck ran back into shovel in pit...............	9-1/2
Bruised side and head...	Fell from truck..................	73
Strained neck...........	Fell from truck..................	9
Bruised back............	Fell from truck..................	17
Strained foot...........	Jumped from truck................	15
Fractured arm...........	Motor back-fired; cranking truck.	88
Leg badly crushed.......	Caught between runaway truck and another standing................	183 to 11/17/38

It will be noted that trucks were involved in 8 of the 11 most serious accidents.

Early in the work the smoke, fumes, and dust seemed to have a definite psychological effect. Two men operating shovels were overcome by fumes, and shortly thereafter a number of other persons claimed ill effects of varied natures due to the same cause. All such cases received medical examination promptly; with a few exceptions, the symptons complained of had nothing to do with the alleged source of trouble. This situation was improved speedily and later eliminated by providing gas masks for shovel operators and dust respirators for others; and providing the general foreman with a carbon monoxide detector, which he used frequently in the presence of other employees with repeated assurance that no dangerous atmospheres existed. His almost constant presence at suspected points of danger is believed to have allayed most of the fear experienced early. That uncomfortable, if not dangerous, conditions existed at times, particularly on calm, cloudy days when smoke and fumes hung in the pit, was not denied, and all persons required to operate machinery in the worst places were urged to seek relief in fresh air as frequently as necessary. Gas masks seldom were used after short trials, although they always were readily available because the men preferred the discomfort without respiratory protection to that experienced in wearing masks.

Forced ventilation was provided during the early and worst stages of the work, and a well-equipped first-aid station was maintained on the ground.

COST ANALYSIS AND MAN-HOURS OF WORK

As the principal aim of this paper is to emphasize the cost of extinguishing this and similar fires, detailed data on cost and employment are included.

TABLE 5.- Employees at St. Nicholas refuse-bank fire job

Description of work	Number of employees	Occupation	Man-days worked
Removing track and miscellaneous initial preparations................	12	Laborers.............	720
	3	Trackmen.............	180
	1	Electrician..........	60
Subtotal---------------	16		960
Building road to fire.......	6	Small shovel operators..........	108
	6	Small shovel oilers..	108
	2	Bulldozer operators..	36
	2	Service truck operators.........	36
	2	Laborers.............	36
	2	Mechanics............	30
Subtotal---------------	20		354
Rock-dusting fire area......	30	Laborers.............	450
	4	Mechanics............	60
	6	Truck drivers........	90
	3	Bulldozer operators..	45
Subtotal---------------	43		645
Churn drilling and application of rock-dust solution.................	6	Drillers.............	160
	6	Drill helpers........	160
	10	Laborers.............	130
	1	Mechanic.............	30
Subtotal---------------	23		480
Ventilation and lighting....	1	Electrician..........	160
	1	Laborer..............	80
Subtotal---------------	2		240
Excavation, casting with 10-W dragline.............	3	Shovel operators.....	550
	6	Oilers...............	1,100
	3	Enginemen............	550
	1	bulldozer operator...	550

TABLE 5.- Employees at St. Nicholas refuse-bank fire job- Contd.

Description of work	Number of employees	Occupation	Man-days worked
	1	Oil house attendant ..	180
Subtotal-------------	14		2,930
Excavation, small draglines and shovel...............	12	Shovel operators......	2,200
	12	Shovel oilers.........	2,200
	9	Pitmen................	1,650
	4	Mechanics.............	730
	1	Blacksmith............	200
	1	Blacksmith helper.....	200
	1	Miner.................	115
	2	Laborers..............	350
	2	Oil house attendants..	360
Subtotal-------------	44		8,005
Trucking burning material to spoil area............	60	Truck drivers.........	8,400
Subtotal-------------	60		8,400
Pumping water and spoil bank operation...........	4	Pipe fitters..........	720
	6	Fire hose attendants..	1,080
	6	Dumpmen...............	1,080
	3	Bulldozer operators...	555
	3	Pump attendants.......	555
	4	Laborers..............	240
Subtotal-------------	26		4,230
Supervision	1	Superintendent........	178
	3	Foremen...............	558
	2	Engineers.............	430
	1	Timekeeper............	179
	1	Clerk.................	178
	1	Master mechanic.......	181
	3	Safety inspectors.....	270
Subtotal-------------	12		1,974
Total man-days-------------			28,218

TABLE 6.- Summary of expenditures

Classification	Rentals on equipment	Repairs			Operating			Total cost
		Labor	Supplies	Total	Labor	Supplies	Total	
Removing track on refuse bank and other initial preparations........	-	-	-	-	$4,821	$768	$5,589	$5,589
Building road to fire area..........	$2,738	$302	$1,500	$1,802	1,980	1,500	3,480	8,020
Rock-dusting to blanket surface of fire...........................	250	-	-	-	3,513	6,558	10,071	10,321
Churn drilling and application of rock-dust solution................	2,663	291	954	1,245	2,763	3,748	6,511	10,419
Ventilation and lighting............	-	-	-	-	1,476	2,488	3,964	3,964
Excavation with 10-W dragline (casting).........................	48,568	4,115	33,311	37,426	16,900	11,292	28,192	114,186
Excavation with 43-B shovel and 52-B, 55-B, and 3-W draglines (loading into trucks and casting)..........	39,236	8,183	39,093	47,276	39,507	19,029	58,536	145,048
Trucking burning material to spoil area............................	1/157,744	-	-	-	-	-	-	157,744
Pumping water from waste house Run Creek and spoil-bank operation....	6,649	500	2,675	3,175	27,978	15,904	43,882	53,706
Power (pumping, ventilation and light)...........................	-	-	-	-	17	3,391	3,408	3,408
Miscellaneous (Social Security, taxes, insurance, percent on labor, and miscellaneous supplies)...........	-	-	-	-	16,755	2,840	19,595	19,595
Total...............................	257,848	13,391	77,533	90,924	115,710	67,518	183,228	532,000

1/ Truck rental includes operation and repair of trucks.

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In addition to information already given, the following general observations are of interest:

During excavation of the fire, it was noted that the Maple Hill refuse material at and near the middle of the fire had fused solidly, while that of the St. Nicholas bank had burned to ashes, which were easily excavated with the draglines. The Maple Hill material is composed of cleaner plant rock more than 8 inches in diameter, while the St. Nicholas bank is breaker refuse less than 8 inches in diameter and containing a much higher percentage of combustible. It is probable that the heat of the St. Nicholas bank caused the Maple Hill bank to fuse.

To shoot this fused material, it was found advisable to load and fire not more than three holes at a time, and cartridges were prepared separately and placed in the holes at a given signal by three men in unison. However, before the holes could be loaded even in this manner, a stream of water was directed into each hole until boiling and steaming had ceased, after which the previously prepared cartridges were placed. In a few cases of misfires, the dynamite detonated in 5 to 15 minutes from the reheating of the material after the holes had been water-cooled.

An interesting feature was the method by which the fire advanced in the St. Nicholas bank. It was noted that the fire proceeded in small fingerlike areas following vents or concentrations of coarser material. As is common on all high banks, most of the coarser material is concentrated at the bottom of the bank or at the junction of two banks or sections of the same bank. As in this instance, concentrations of coarser material usually are found in lines parallel to the slope of the bank. Thus, a grate and multiple chimney effect is produced by which air is drawn through the fire area making it difficult or even impossible to control by blanketing with limestone dust, earth, sand, clay, or other similar material. In digging out such fires, the fingerlike spread may allow the drilling of exploratory holes to indicate the actual limits of the fire.

It appears that if a barrier to the extension of a fire in waste banks of similar material is to be made by introducing a suspension of rock dust in water, the drill holes should not be more than 10 to 12 feet apart, as the spread of the rock dust here did not exceed 6 to 8 feet radially from the holes. The distance would vary, of course, with the nature of the refuse, temperatures due to the fire, and possibly other conditions.

While excavating the burning material in the vicinity of churn drill holes 1, 3, and 4, it was found that the rock dust, which had been applied through the churn-drill holes as solution, was deposited only on the outer limits of the fire. It is probable that when the rock-dust solution came in contact with the hot material it was converted to steam and carried the rock dust with it until the steam was condensed at the outer limit of the fire and the rock dust was deposited in a chalklike mass, filling the voids within the bank material and cementing the material together. In the vicinity of hole 3, wherein temperatures above 700° F. were recorded, pinkish crystals were noted and later identified as a double salt of ammonium-magnesium sulfate. While these appeared to be at or near the limit of penetration of the rock dust from the drill hole and were formed in the cavities between particles of bank material, it is not clear whether they were formed directly from the original rock dust by a selective reacti between coal distillation products and magnesium that may have been in the rock dust or whether they were deposited from previous solution of other materials.

CONCLUSIONS

Frequent inspections of surface waste piles and recording of subsurface temperatures with analyses of the gases occurring a few feet beneath the surface are of value in preventing firing and certainly in discovering a fire or tendency to fire in the incipient stages. These data can and should be obtained by drilling holes a few feet in depth wherever evidence of heating is noted, as for example the presence of steam or smoke or the melting of snow in the winter. If such procedures are not feasible for all mining companies, at least cooperative interpretation of results and observations is desirable.

The difficulties, time, labor, and costs involved in extinguishing waste-bank fires are evident in the present instance, but even if they are greater than has been recorded previously, they are strong support for the contention that experimental and research work may well be directe toward development of cheaper and better methods for extinguishing such fires. As a corollary to this statement, more care should be exercised to prevent firing of waste piles, but the practical fact that they do fire is justification enough for the previous statement.